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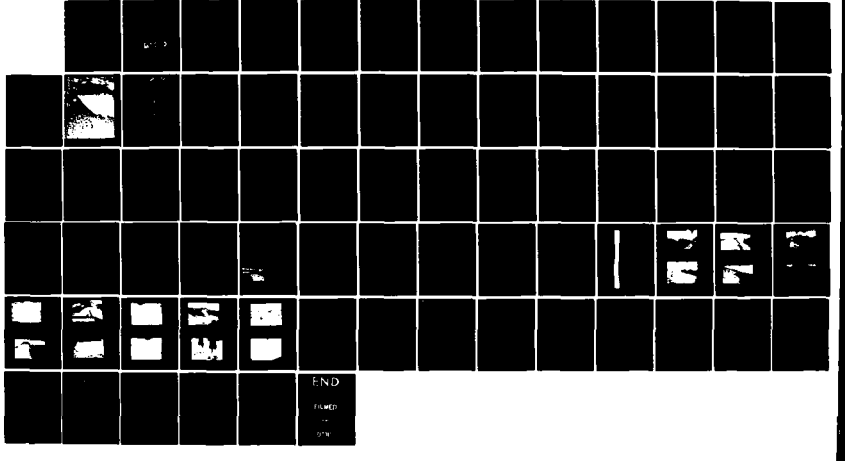

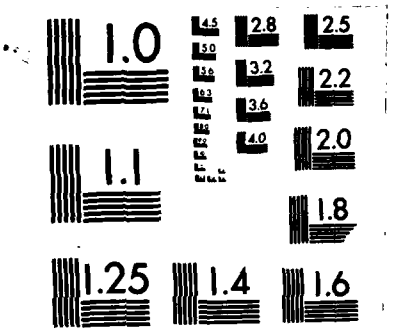

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CONNECTICUT RIVER BASIN

HANOVER, NEW HAMPSHIRE

UPPER RESERVOIR DAM

NH 00049

NHWRB NO. 10806

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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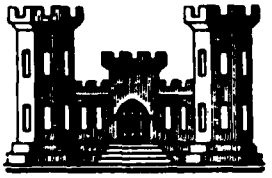

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Hanover New Hampshire
Camp Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is an earthen structure with an overall length of 1340 ft. The dam has a height of 30 ft. The dam is considered to be in good condition. It is small in size with a significant hazard potential.

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UPPER RESERVOIR DAM

NH 00049

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CONNECTICUT RIVER BASIN
HANOVER, NEW HAMPSHIRE

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF
NEDED

MAR 0 6 1980

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the Upper Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Hanover Water Works Company.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

LETTER OF TRANSMITTAL

FROM THE CORPS OF ENGINEERS TO THE STATE

TO BE SUPPLIED BY THE CORPS OF ENGINEERS

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: 00049

Name of Dam: Upper Reservoir Dam

Town: Hanover

County and State: Grafton, New Hampshire

Stream: Camp Brook

Date of Inspection: October 26, 1979

Upper Reservoir Dam is a earthen structure with an overall length of 1340 feet. The dam has a height of 30 feet, as measured from the streambed to the crest of the dam. The top width is 9 feet. The upstream face is on a 2.25 horizontal to 1 vertical slope and the downstream slope is 2 horizontal to 1 vertical. The spillway consists of a 25 feet long crest, concrete weir with training walls, which outlets to a 10 foot wide stone wall channel. There are two intakes with 10 inch diameter pipes which divide into two 10 inch and one 6 inch line. Each line is gated separately with gate valves sized to the respective line diameters. Each pipe discharges to a jet for aeration prior to entering the main spillway discharge channel. The dam, originally constructed in 1924, was reconstructed and raised in 1950. The impoundment is used for water supply. There are plans of the dam available, however, no design calculations or construction data were revealed.

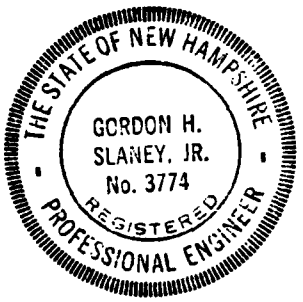
The visual inspection revealed that the dam is in good condition. The inspection revealed two wet areas at the downstream toe of the dam and several collapses of the stone wall of the spillway discharge channel.

Based on a maximum storage of 730 acre-feet and a height of 30 feet, Upper Reservoir Dam falls within the small size classifiction. The dam's hazard classification has been established as significant based on the potential flood wave overtopping Lower Reservoir Dam. Based on the small size of the dam and its significant hazard classification and in accordance with Corps of Engineers Guidelines, the test flood inflow should be of a magnitude ranging from a 100 year frequency flood to 1/2 the Probable Maximum Flood (PMF). One half the PMF was used for the test flood inflow, which is 1245 cfs. The routed test flood outflow of 780 cfs overtops the dam by approximately 0.1 feet.

With the water surface at the top of dam the spillway capacity without flashboards is approximately 550 cfs (about 71 percent of the routed test flood outflow).

It was recommended that the owner engage a qualified, registered professional engineer to perform a visual inspection of the dam during dry weather so it can be determined if the wet areas observed during the Phase I investigation were a result of surface runoff or seepage beneath the dam, in addition a way of removing flashboards during high water should be devised so that they can be removed without exposing personel to hazardous conditions. Remedial measures include the development of a downstream warning system and repair of portions of the stone wall along the spillway discharge channel.

The recommendations are described in Section 7.2 and should be addressed within 1 year, after receipt of this Phase I - Inspection Report by the owner. The remedial measures are described in Section 7.3 and should be addressed within 2 years.



Gordon H. Slaney, Jr.

Gordon H. Slaney, Jr., P.E.
Project Engineer

HOWARD NEEDLES TAMMEN & BERGENDOFF
Boston, Massachusetts

This Phase I Inspection Report on Upper Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might be otherwise detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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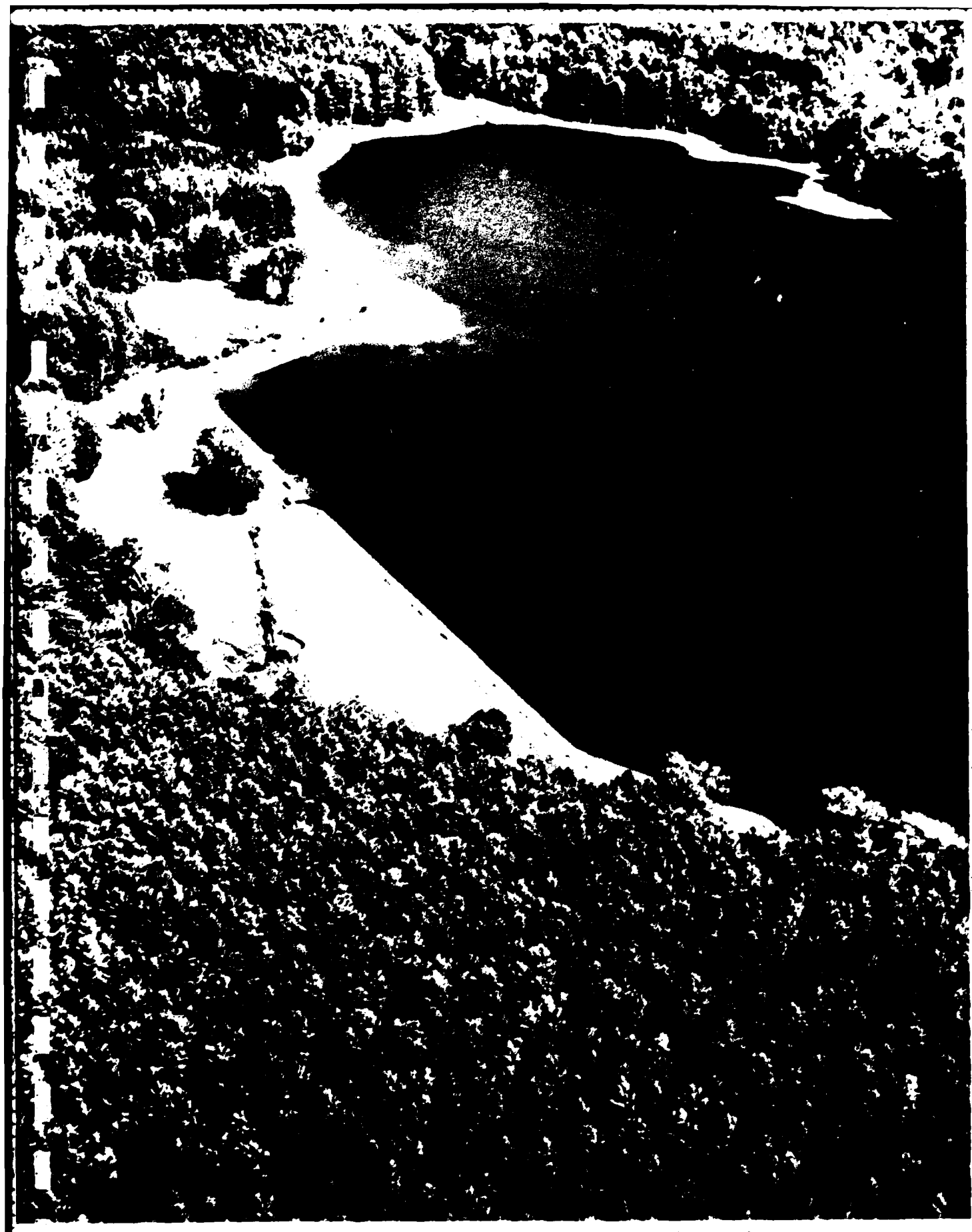
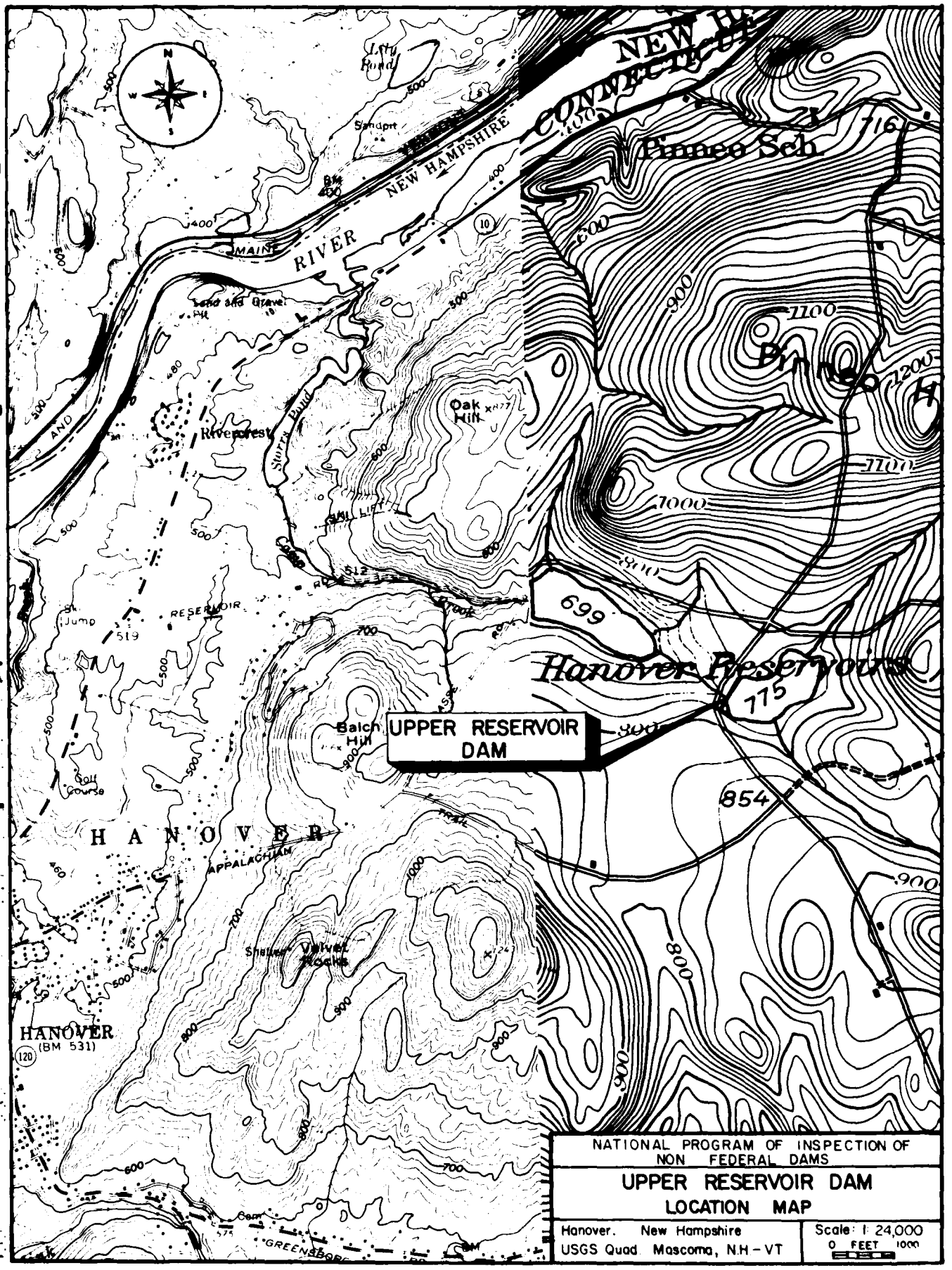


Upper Reservoir Dam - Overview from above left abutment



NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

UPPER RESERVOIR DAM

LOCATION MAP

Hanover, New Hampshire
USGS Quad Mascoma, N.H - VT

Scale: 1:24,000
0 FEET 1000

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Howard, Needles, Tammen & Bergendoff has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to Howard, Needles, Tammen & Bergendoff under a letter of October 11, 1979 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-79-C-0060 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Upper Reservoir Dam is located on Camp Brook approximately 2.4 miles upstream of the Connecticut River in the Town of Hanover, New Hampshire. The dam is shown on U.S.G.S. Quadrangle, Mascoma, New Hampshire-Vermont, with approximate coordinates N43°42'52", E72°14'18", Grafton County, New Hampshire. The location of Upper Reservoir Dam is shown on the preceding page.

b. Description of Dam and Appurtenances. Upper Reservoir Dam is an earthen embankment structure with an overall length of 1,340 feet. The dam has a maximum height of 30 feet as measured from the dam crest to the streambed. The crest of the dam is 9 feet wide. The upstream face is on a 2.25 horizontal to 1 vertical slope and the downstream embankment is on a 2 horizontal to 1 vertical slope. The present dam is constructed on the old dam. The new embankment was placed on the crest and downstream slope of the old dam. The present crest is 5 feet above the old crest. In cross-section the embankment consists of a wedge section of impervious material against the downstream face of the old dam backed by a section of semi-pervious material. The outside portion of the downstream face consists of a layer of pervious material spread with loam and an established vegetative cover. The upstream face has riprap protection from mid-height to the crest.

Appurtenant structures consist of a spillway and discharge channel and two 10 inch diameter outlet pipes. The spillway has a 25 foot long concrete weir crest. The spillway crest is 3.6 feet below the dam crest. There are flashboards 1.4 feet high on the spillway crest. The concrete training walls extend 15 feet upstream of the spillway crest and 25 feet downstream. The spillway discharges directly onto exposed ledge. The outlet channel bends to the left immediately downstream of the dam and is about 10 feet wide with dry masonry stone walls. The two 10 inch diameter cast iron outlet pipes have intakes near the upstream toe of slope. Each pipe enters a manhole at the downstream toe of slope. The manhole covers are flush with the ground surface. One line is gated with a 10 inch gate valve and discharges to a 10 inch diameter aerated jet in the spillway discharge channel. The other 10 inch line divides to a 10 inch and 6 inch diameter lines at a wye in the manhole. Each line is gated with a gate valve downstream of the wye. Each line discharges to an aerated jet 4 and 3 inches in diameter, respectively.

Figures 1 and 2 located in Appendix B, show a plan of the dam and its appurtenant structures. Photographs of each structure are shown in Appendix C.

c. Size Classification. Small (hydralic height - 30 feet, storage 730 acre-feet) classification based on the hydraulic height being less than 40 feet and the storage being less than 1,000 acre-feet as given in Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. The potential for damage posed by this dam is classified as significant. Failure of the dam with the water level at the top of dam would result in a flood wave about 17 feet high in the reach extending from the dam to

the upstream end of Lower Reservoir located 1,300 feet downstream. There are no structures in that reach. However, the storage in Upper Reservoir is great enough to raise the level of Lower Reservoir and cause overtopping of the Lower Reservoir Dam, thus endangering that dam.

e. Ownership. This dam is owned by the Hanover Water Works Company, P.O. Box 1006, Hanover, New Hampshire 03755.

f. Operator. This dam is operated by the Hanover Water Works Company, Mr. Carl Brink, Superintendent, P.O. Box 1006, Hanover, New Hampshire, Telephone No. 603-643-3506.

g. Purpose of Dam. The impoundment is used exclusively for water supply. The reservoir is one of three in a system. Reservoir No. 3 is located above and in another watershed than Upper Reservoir and discharges to Upper Reservoir via a 10 inch diameter gravity pipeline. Upper Reservoir discharges to Lower Reservoir through the two 10 inch diameter outlet pipes which empty to a stream tributary to Lower Reservoir.

h. Design and Construction History. Upper Reservoir Dam was constructed in 1924. In 1950, the original structure was raised 5.0 feet and the spillway was reconstructed. No modifications to the dam have been made since 1950.

i. Normal Operating Procedures. Upper Reservoir provides additional storage for the Hanover water system. Water is released as required to the Lower Reservoir. The outlet pipes discharge to jets which operate by the head supplied from the reservoir. Flashboards on the spillway crest are removed from December to April. The lake level fluctuates according to the water supply demand.

1.3 Pertinent Data

a. Drainage Area. The area tributary to Upper Reservoir consists of 0.83 square miles of mountainous wooded terrain. There is no development in the watershed which is owned by the Hanover Water Works Company. Maximum elevation in the basin is 1,280 feet NGVD. There are three other peaks over elevation 1,000. The average water surface in the reservoir is about elevation 784.0.

A large portion of the reservoir bank is riprapped at the waterline. Above the riprap the banks are clear of trees for a distance of 10 to 15 feet. Beyond that point the area is heavily wooded. There are no islands in the reservoir or nearby structures.

b. Discharge at Dam Site.

(1) Outlet works for Upper Reservoir consist of two intakes located at the upstream toe of slope. The inverts of the intakes are unknown, but are estimated to be at about elevation 765.0. Ten inch cast iron pipe connects each intake to a separate manhole where one line is gated with a 10 inch gate valve and the other line divides into a 10 inch line and a 6 inch line, each of which is gated downstream of the wye with a 10 inch gate valve and a 6 inch gate valve, respectively.

(2) There are no records of maximum discharge at the site.

(3) The spillway capacity with the water surface the top of dam, elevation 790.5, would be about 550 cfs without flashboards in place and 290 cfs with the flashboards in place.

(4) The spillway capacity with the water surface at the test flood elevation of 790.6 would be about 580 cfs.

(5) The total project discharge at the test flood elevation of 790.6 is approximately 780 cfs.

c. Elevation (feet above NGVD)

(1) Streambed at centerline of dam - 760.5

(2) Maximum tailwater - unknown

(3) Upstream invert of outlet works - 765.0 estimated

(4) Normal pool - 786.9

(5) Full flood control pool - N/A

(6) Spillway crest (permanent spillway) - 786.9

(7) Design surcharge - N/A

(8) Top Dam - 790.6

(9) Test Flood Surcharge -790.6

d. Reservoir (miles)

(1) Length of Maximum Pool - 0.31

(2) Length of Normal Pool - 0.30

(3) Length of Flood Control Pool - N/A

e. Storage (gross acre-feet)

(1) Normal Pool - 580

(2) Flood Control Pool - 580

(3) Spillway Crest Pool - 580 without flashboards

(4) Top of Dam - 730

f. Reservoir Surface (acres)

(1) Normal Pool - 46

(2) Flood Control Pool - N/A

(3) Spillway Crest - 46

(4) Test Flood Pool - 46

(5) Top Dam - 46

g. Dam

(1) Type - earth

(2) Length - 1,340 feet

(3) Height - 30 feet

(4) Top Width - 9 feet

(5) Side Slopes - upstream 2.25 horizontal to 1 vertical
downstream 2 horizontal to 1 vertical

(6) Zoning - 3 zones

(7) Impervious core - yes material unknown

(8) Cutoff - unknown

(9) Grout Curtain - unknown

(10) Other - unknown

h. Diversion and Regulating Tunnel

See Section j below.

i. Spillway

(1) Type - concrete weir

(2) Length of Weir - 25 feet

(3) Crest Elevation - 786.9

(4) Controls - Flashboards 1.4 feet high, removable

(5) Upstream Channel - none

(6) Downstream Channel - The spillway outlets to a 10 foot wide channel with dry masonry stone walls. The channel turns to the left immediately downstream of the spillway and almost parallels the downstream toe of slope for 150 feet where it joins the jets which are part of the outlet works. The channel then makes a right angle turn downstream and passes under a bridge for the access road which has a 10 foot wide by 5 foot high opening.

j. Regulating Outlets. The outlet works consist of two 10 inch diameter cast iron pipes which divide into three pipes. Each of the three pipes are gated with gate valves of the same sizes as the lines. Each pipe discharges to a jet for aeration prior to open channel transportation to Lower Reservoir. Capacity of the three jet outlets with the water surface at the spillway crest would be about 10 cfs.

SECTION 2
ENGINEERING DATA

2.1 Design

Plans of the 1950 reconstruction of Upper Reservoir Dam are on file with the New Hampshire Water Resources Board. These plans also show the original 1924 dam. Design was done by Weston & Sampson, Boston, Massachusetts. No specifictions or design calculations were made available. There is no record of any modifications to the dam since the 1950 reconstruction.

2.2 Construction

No construction records are available for use in evaluating the dam.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. Information available consists of a set of 3 plan sheets and an inspection report by the New Hampshire Water Resources Board. The above data is available at the Department's offices in Concord, New Hampshire.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Validity. The field inspection indicated that the external features of Upper Reservoir Dam substantially agree with those shown on the available plans.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Upper Reservoir Dam was made on October 26, 1979. The inspection team consisted of personnel from Howard, Needles, Tammen & Bergendoff and Geotechnical Engineers, Inc. A representative of the owner was also present during the inspection. Inspection checklists, completed during the inspection, are included in Appendix A. At the time of inspection, the water level was approximately 5.8 feet below the permanent spillway crest. The upstream face of the dam could only be inspected above this level.

b. Dam. Visual inspection of the dam indicated that it is in good condition.

The dam consists of an earth embankment about 1340 feet long and 30 feet high. The axis of the embankment is serpentine along its length with the right half of the embankment practically perpendicular to the main embankment section.

A concrete spillway section passes through the main embankment section.

Upstream Slope

The inclination of the upstream slope is 2.25 horizontal to 1 vertical. The upstream slope is shown in Photo No. 4. The riprap is in good condition and there are no indications of sloughing or erosion on the slope.

Crest

The crest of the dam is 9 feet wide and, as shown in Photo No. 4, is uniformly grass covered.

Downstream Slope

The downstream slope of the embankment is inclined at 2 horizontal to 1 vertical and is shown in Photo No. 5. The slope is uniform and covered with an excellent grass cover.

There is a wet area which contains standing water located at the downstream toe about 50 feet left of the aeration jets. The wet area extends 50 feet along the toe of the embankment and extends 60 feet downstream of the toe. This area is shown in Photo Nos. 7 & 8.

It is not possible to state explicitly if the wet area is due to seepage from beneath the dam or is a result of local ponding of surface runoff. An inspection report from the New Hampshire Water Resources Board dated May 23, 1977 states that no seepage was observed.

A swampy area exists at the toe of the dam at the point where the embankment makes a sharp turn. This area is shown in Photo No. 6. This swampy area is about 3 feet below the normal reservoir high water level, and it is likely that the swamp is due to local surface runoff. At the time of inspection, the water surface in the reservoir was below the level of the swamp.

c. Appurtenant Structures. Visual inspection of the concrete spillway, spillway channel and outlet works did not reveal any evidence of stability problems. The concrete surface at the spillway structure generally appeared to be in good condition except for three, rather insignificant cracks in training walls. The spillway channel with unmortared field stone is in fair condition.

The spillway structure, shown in Photo Nos. 9, 10 & 11, consists of a gravity concrete weir structure and two training walls. The spillway crest is in good condition. The concrete training walls are also in good condition except for two cracks in the right wall and one insignificant crack in left wall as seen in Photo No. 12. The wingwalls and flashboards are in excellent condition. (Photo No. 10). However, there is no means of removing the flashboards during high water without exposing personel to hazardous conditions.

The outlet works include two intake structures, piping, two valve manholes and discharge jets. The intake structures were under water and could not be inspected. The valve manholes had covers flush with the ground that are normally locked. The discharge jets outlet to the spillway channel. The two smaller diameter jets were in operation as seen in Photo No. 15. The larger 10 inch diameter jet is located to the right side of Photo No. 10 and was covered with a flat stone. The outlet works appeared to be in good condition.

Visual inspection of the spillway discharge channel seen in Photo No. 14 showed it to be in fair condition. The sides of the channel are reinforced with dry stone masonry. The bottom of the channel was covered with loose stone and some vegetation has established itself along the bed. The dry stone masonry has collapsed in several areas.

d. Reservoir Area. The immediate banks of the reservoir are paved with rip-rap at the water line. An overview of the reservoir area from the dam is shown in Photo No. 1. There are

no overhanging trees and no debris along the banks although the area surrounding the reservoir is heavily wooded.

e. Downstream Channel. The stone wall discharge channel ends about 90 feet downstream of the toe of slope of dam where there is a bridge for the access road as seen in Photo No. 16. The water way opening is clear of debris. Downstream of the bridge the channel is natural with a 10 foot bottom width. The bridge is in fair condition, with some spalling of concrete. There is a high steep bank on the left side. Both overbanks are heavily wooded.

3.2 Evaluation

Visual examination indicates that the dam is in good condition. Visual examination revealed the following:

(a) There is a wet area at the downstream toe of the dam embankment 50 feet to the left of the aeration jets.

(b) A second wet area, a swamp, was noted near the right end of the dam.

(c) Several collapses of the dry stone wall of the discharge channel.

(d) There is no means of removing the flashboards during high water without exposing personel to hazardous conditions.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure

Upper Reservoir Dam is used exclusively for water supply. Upper Reservoir receives water from Reservoir No. 3 via a 10 inch diameter pipe. Reservoir No. 3 is located in a different watershed. It discharges to Lower Reservoir via a natural stream channel. Lower Reservoir discharges to the water distribution system by gravity pipe. All exchanges of water are based upon water supply demand and the lake level flucuates accordingly. Flashboards, 1.4 feet high, on the spillway are removed from December to April of each year.

4.2 Maintenance of Dam

The dam is inspected on a daily basis by personnel of the Hanover Water Works Company. Vegetation on the crest and downstream slope is cut at least once a year. Repairs are made when required.

4.3 Maintenance of Operating Facilities

The operating facilities are in constant use and inspected during use with repairs made as needed.

4.4 Description of Warning Systems

There are no warning systems in effect for this facility.

4.5 Evaluation

The current operational and maintenance procedures appear to be adequate to insure that normal problems encountered can be remedied within a reasonable period of time. However, the owner should arrange to have a technical inspection made on an annual basis.

The owner should establish a written operational procedure as well as establishing a warning system to follow in the event of emergency conditions.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. General. Upper Reservoir Dam is an earthen embankment structure with an overall length of 1,340 feet and a maximum height of 30 feet. The crest is 9 feet wide and a vegetative cover is established on the crest and downstream slope. Appurtenant structures consist of a spillway and outlet works. The spillway weir is concrete and has a crest length of 25 feet. The concrete training walls are normal to the spillway crest and are 3.6 feet higher than spillway crest. Immediately downstream of the spillway the channel is on ledge and enters a 10 foot wide dry masonry, stone wall channel. Outlet works consist of two 10 inch diameter intake pipes. Each pipe is gated in a manhole. One pipe divides to a 6 inch and 10 inch diameter pipe with gate valves downstream of the dividing point.

The impoundment is used for water supply by the Hanover Water Works Company. The dam is classified as intermediate in size with a height of 30 feet and a maximum storage of 730 acre-feet.

b. Design Data. Plans of the reconstruction of the original dam were available, however, no hydraulic or hydrologic design data were availble.

c. Experience Data. There are no records of maximum discharge at the site.

d. Visual Observations. No evidence of damage to any portion of the project from overtopping was visible at the time of inspection.

e. Test Flood Analysis. No detailed design and operational information are available for this dam. The hydrologic evaluation was performed using information gathered by field investigation, watershed characteristics, and Probable Maximum Flood (PMF) curves prepared by the Corps of Engineers. In accordance with Corps of Engineer Guidelines the significant hazard classification and small size classification of this dam warrants a test flood magnitude ranging from a 100-year frequency flood to one-half the PMF. A test flood equal to 1/2 the PMF was used. A test flood inflow of 1,245 cfs is based on a watershed of .83 square mile in mountainous terrain.

The routed test flood outflow was determined in accordance with Corps of Engineers Guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharge, and the hydraulic characteristics of the dam. Spillway discharge was computed as flow over a weir. Discharge over the crest of the dam was computed as flow over an embankment using the weir discharge equation. It was assumed that the flashboards were not in place. The routing was started with the water surface at the crest of the spillway. The routed test flood outflow was determined to be approximately 780 cfs. As the maximum capacity of the spillway is approximately 550 cfs (about 71 percent of the routed test flood outflow) the dam will be overtopped by 0.1 feet.

f. Dam Failure Analysis. The impact of failure of the dam was assessed using the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs prepared by the Corps of Engineers. The breach discharge was estimated with the water surface at the crest of the dam and a breach width equal to 40 percent of the length of the dam at mid-height. The downstream hydrograph is a sum of the breach discharge and the maximum spillway discharge. Prior to the breach of dam the downstream river stage would be about 3.5 feet, with the spillway at a full capacity discharge of 550 cfs. Breach of dam would result in an additional 33,150 cfs for a total of 33,700 cfs. The downstream stage was estimated using an average channel cross section in the reach between the dam and Lower Reservoir located 1,300 feet downstream. The stage through this reach would be about 17 feet. The only structure in this reach is the access road bridge downstream of the dam which would be inundated by about 15 feet. If at the time of breach the level of Lower Reservoir is at the spillway crest, there will be approximately 119 acre-feet of surcharge storage available in Lower Reservoir. Discounting spillway discharge at Lower Reservoir and attenuation of the breach discharge with time it would take about 3 minutes for the Lower Reservoir Dam to be overtopped by the flood wave.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation. The visual inspection of Upper Reservoir Dam did not reveal any immediate stability problems

b. Design and Construction Data. Design drawings dated May 1950 which delineate the design for raising an existing dam at the site were available for review. The drawings indicate that the earlier dam was an embankment dam and that the addition raised the old dam 5 feet by placing a zoned embankment directly on the downstream slope of the original dam.

Specifications indicate that the added embankment as compacted in 6- or 10-inch-thick lifts.

The addition was constructed with a wide impervious upstream section, a semi-pervious downstream section which was covered with a sloping pervious section forming the downstream face.

c. Operating Records. No operating records were made available.

d. Post-Construction Changes. There is no record of changes since the raising of the original dam as described in Section 6.2.

e. Seismic Stability. The dam is located in Seismic Zone 2, and in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual inspection of Upper Reservoir Dam indicates that the dam is in good condition. The inspection revealed the following:

(1) There is a wet area at the downstream toe of the dam embankment 50 feet to the left of the aeration jets.

(2) A second wet area, a swamp, was noted near the right end of the dam. The area may be due to surface runoff.

(3) Several collapses of the dry stone wall of the spillway discharge channel.

(4) There is no means of removing the flashboards during high water without exposing personel to hazardous conditions.

The hydraulic analysis reveals that the spillway cannot pass the routed test flood without overtopping the dam.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. This dam is in generally good condition. The recommendations described in Section 7.2 should be accomplished within 1 year, after receipt of this Phase I Inspection Report by the owner. The remedial measures described in Section 7.3 should be accomplished within 2 years.

d. Necessity of Additional Investigation. No additional investigation is needed to complete the Phase I inspection.

7.2 Recommendations

The owner should engage a qualified, registered professional engineer to perform a visual inspection of the dam during a period of dry weather so it can be determined if the wet areas observed during this Phase I investigation were the result of surface runoff or seepage beneath the dam. In addition, a way of removing the flashboards should be devised so that they can removed during high water conditions without exposing personel to hazardous conditions.

7.3 Remedial Measures

(a) Repair the collapses in the stone walls along the spillway discharge channel.

(b) Prepare a downstream warning system in the event of an emergency.

(c) A technical inspection program should be initiated and continued on a biennial basis.

(d) Establish a system such that the reservoir level can be monitored during periods of intense rainfall.

7.4 Alternatives

There are no practical alternatives to the recommendations of Sections 7.2 and 7.3.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Upper Dam (Hanover)

DATE 10/26/79

TIME 12:00 PM

WEATHER Cloudy

W.S. ELEV. 781.1 U.S. - DN.S

PARTY:

1. D. LaGatta GEI
2. S. Mazur HNTB
3. R. Yarsites HNTB
4. Carl Brink, Hanover Water Works Company
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	Dan LaGatta	
2.	Spillway, outlet and	Stan Mazur	
3.	Downstream Channel	Robert Yarsites	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER HANOVER RESERVOIR DATE 10/26/79

PROJECT FEATURE Embankment Dam NAME D. LaGatta

DISCIPLINE Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	790.5
Current Pool Elevation	781.1
Maximum Impoundment to Date	Unknown.
Surface Cracks	None observed.
Pavement Condition	No pavement.
Movement or Settlement of Crest	None observed.
Lateral Movement	No misalignment observed.
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	No structures on slopes.
Trespassing on Slopes	None.
Sloughing or Erosion of Slopes or Abutments	None.
Rock Slope Protection - Riprap Failures	Riprap in good condition.
Unusual Movement or Cracking at or near Toes	Non observed.
Unusual Embankment or Downstream Seepage	Standing water extending 50 ft along toe and 60 ft d.s. of toe. Located 50 ft left of outlet jets.
Piping or Boils	No piping or boils observed.
Foundation Drainage Features	None.
Toe Drains	None.
Instrumentation System	None.
Vegetation	Grass slopes in good condition.

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE Intake Structure NAME D. LaGatta

DISCIPLINE Geotechnical/Structural NAME S. Mazur

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	Outlet is below reservoir surface.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	Intake structure - under water.
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE Control Tower NAME S. Mazur

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	This facility has no tower. Controls for drain pipes are located in concrete chamber at toe of the dam.
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE Outlet Works Conduit NAME S. Mazur

DISCIPLINE Structural/Hydraulic NAME R. Yarsites

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	The pond is drained by a 10 inch pipes as shown in Figure 1. The pipes are controlled by valve located in control chamber. The pipe and control appeared to be in good condition.
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE Outlet Structure/Channel NAME R. Yarsites, S. Mazur

DISCIPLINE Hydraulic,Structural, Geotechnical NAME D. LaGatta

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Good condition. Outlet works consists of a 10 inch pipe with controls.
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	
Loose Rock or Trees Overhanging Channel	The outlet channel for the aerator jets is coincident with the lower portion of the spillway discharge channel. The channel walls are formed of dry stone masonry.
Condition of Discharge Channel	No trees overhanging channel and general condition is good.

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE Outlet Works - Spillway NAME D. LaGatta, R. Yarsites

DISCIPLINE Geotechnical, Hydraulic, Structural NAME S. Mazur

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	
Loose Rock Overhanding Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	Good condition. Two cracks at right training wall and one at left training wall were noted.
General Condition of Concrete	
Rust or Staining	None
Spalling	None
Any Visible Reinforcing	None noted.
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	
General Channel	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

PERIODIC INSPECTION CHECK LIST

PROJECT Upper Dam DATE 10/26/79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	This facility has no service bridge.
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

ENGINEERING DATA

1. LIST OF DESIGN, CONSTRUCTION AND MAINTENANCE RECORDS
2. PAST INSPECTION REPORTS
3. PLAN AND DETAILS

AVAILABLE ENGINEERING DATA

1. A set of drawings (3 sheets), dated May 1950, showing the original dam and proposed changes. The plans are on file with the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire.

PAST INSPECTION REPORTS

NEW HAMPSHIRE WATER RESOURCES BOARD

B-1

INSPECTION REPORT

Town: Hanover Dam Number: 103.06

Name of Dam, Stream and/or Water Body: Upper Res

Owner: Hanover Water Works Co Telephone Number:

Mailing Address: Hanover

Max. Height of Dam: 30' Pond Area: Length of Dam: 1340

FOUNDATION: Earth

OUTLET WORKS: 25 long overflow spillway with Flashboards

ABUTMENTS: Concrete in Good shape

EMBANKMENT: Earth Embankment 2:1 Slopes · 10' wide top
Stone paving upstream with vegetated Top and downstream

Note: Give Sizing, Condition and detailed description for each item, if applicable.

B-2

SPILLWAY: Length: _____ Freeboard: _____

SEEPAGE: Location, estimated quantity, etc.

None

Changes Since Construction or Last Inspection:

Tail Water Conditions:

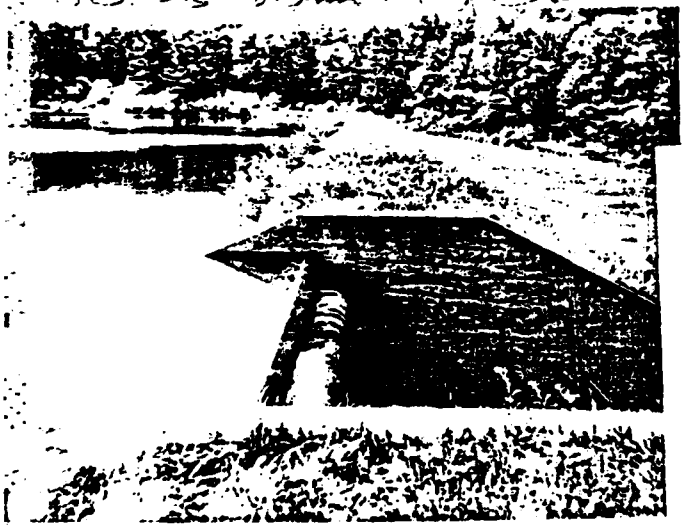
Overall Condition of Dam: Good

Contact With Owner: No

Date of Inspection: 23 May 77 Suggested Reinspection Date 1990

Class of Dam: Small, B

02.05 23 May 77 J Barnett



Signature J Barnett

Date _____

02.06 23 May 77

Note: Give Sizing, Condition and detailed

B-3

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN Connecticut NO. 106.06 0.92
RIVER Camp Brook MILES FROM MOUTH ____ D.A.SQ.MI [illegible]
TOWN Hanover OWNER Hanover Water [illegible]
LOCAL NAME OF DAM Upper Reservoir
BUILT ____ DESCRIPTION Earth fill, riprap upstream, concrete spillway

POND AREA-ACRES 22.4 DRAWDOWN FT. ____ POND CAPACITY-ACRE FT. ____
HEIGHT-TOP TO BED OF STREAM-FT. 20± MAX. ____ MIN. ____
OVERALL LENGTH OF DAM-FT. [illegible] MAX.FLOOD HEIGHT ABOVE CREST-FT. ____
PERMANENT CREST ELEV.U.S.G.S. 775 LOCAL GAGE ____
TAILWATER ELEV.U.S.G.S. ____ LOCAL GAGE ____
SPILLWAY LENGTHS-FT. 11 [illegible] FREEBOARD-FT. ____
FLASHBOARDS-TYPE,HEIGHT ABOVE CREST ____
WASTE GATES-NO. WIDTH MAX.OPENING DEPTH SILL BELOW CREST ____

REMARKS Condition Good
36 into Camp Brook, Connecticut R.

POWER DEVELOPMENT

UNITS NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	MAKE

USE Water Supply Town of Hanover

REMARKS Not listed on P.S.C. map. [illegible]
[illegible]
[illegible] of P.S.C.
Planning Board gives area of both ponds as 61.5± acres at elevations 699 and 775

DATE ____

9/7/37 [illegible]

FORM E2 3722

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

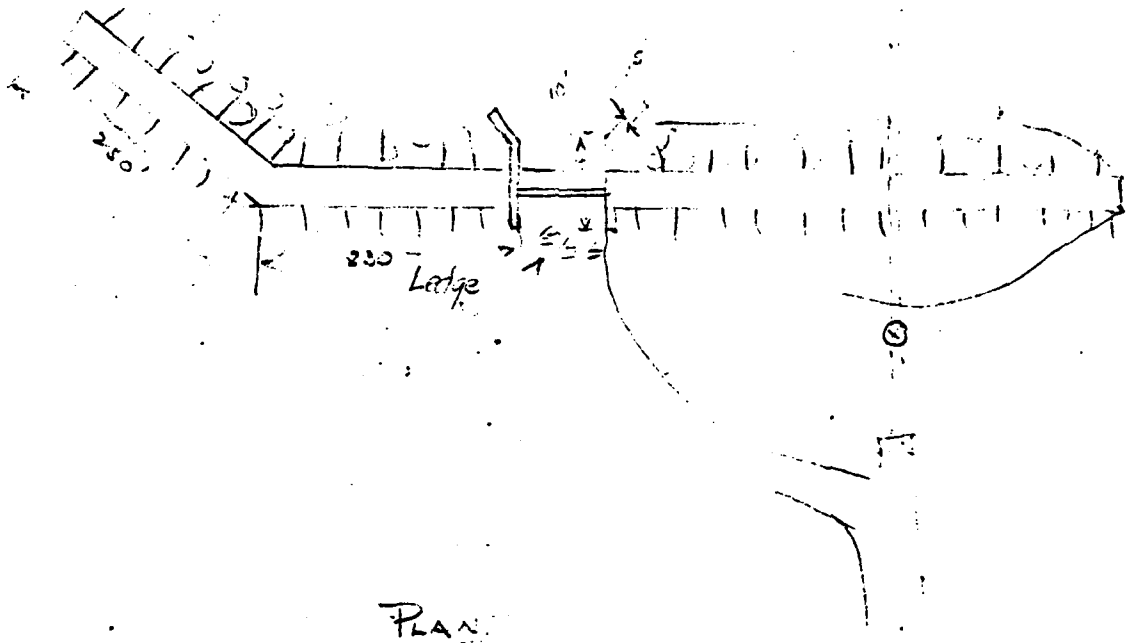
PROJECT

FILE B-4

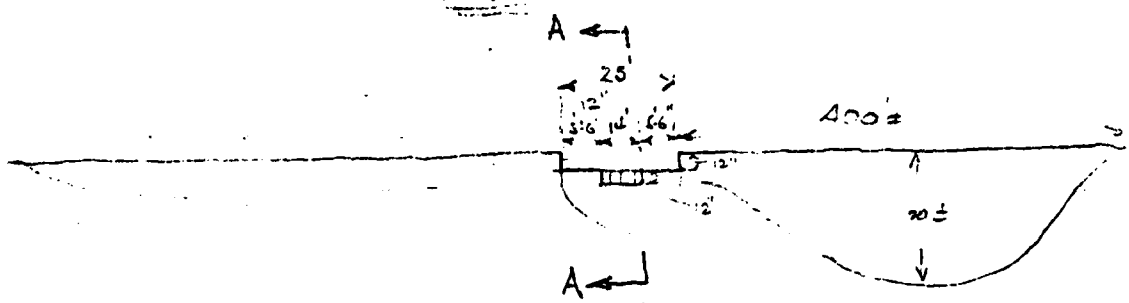
SUBJECT HANOVER RESERVOIR - UPPER DAM

ACC.

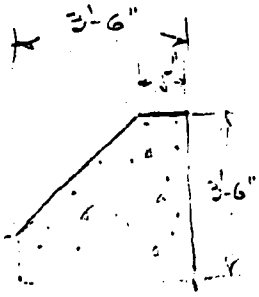
COMPUTER CHECKER CONT FROM ACC. CONT. ON ACC. SUMMARY ON ACC. DATE



PLAN



PROFILE



SEC. A-A.

Condition Good

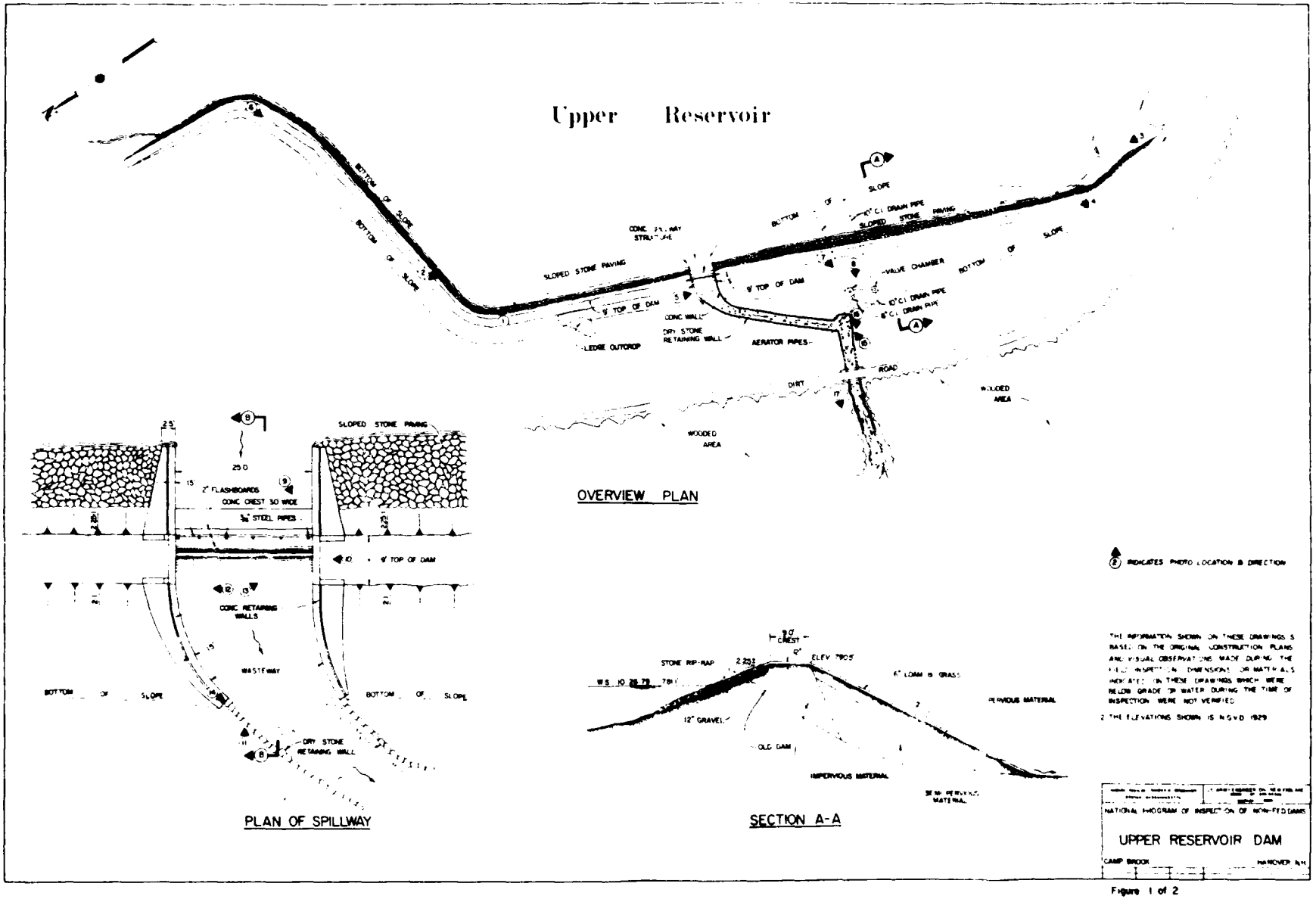
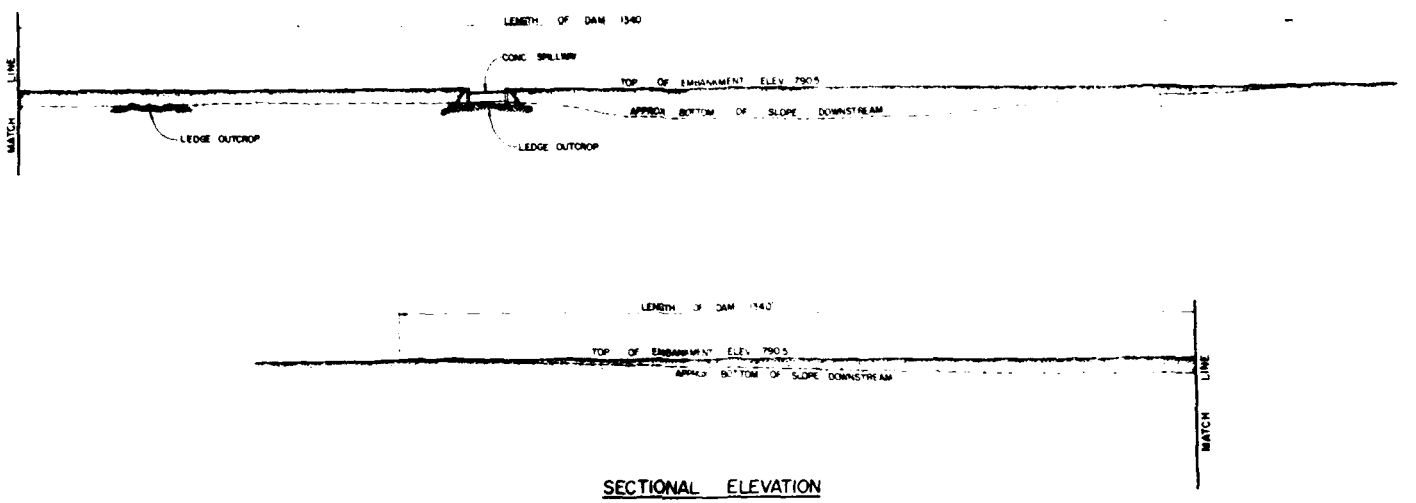
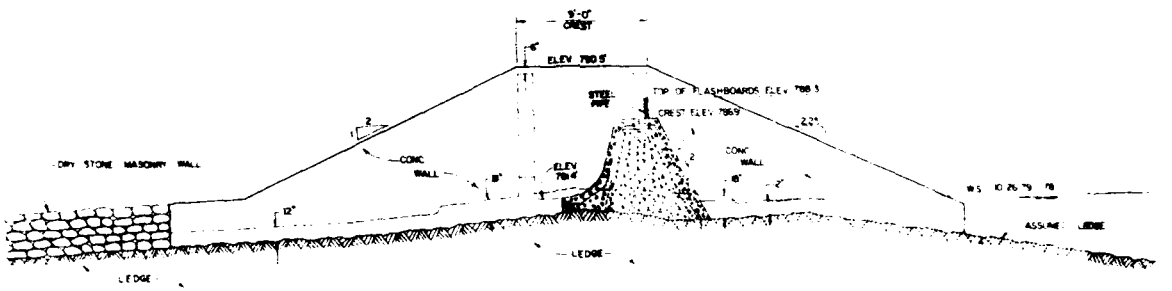


Figure 1 of 2

REPRODUCED AT GOVERNMENT EXPENSE



SECTIONAL ELEVATION



SECTION B-B

1. THE INFORMATION SHOWN ON THESE DRAWINGS IS BASED ON THE ORIGINAL CONSTRUCTION PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THESE DRAWINGS WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.
2. THE ELEVATIONS SHOWN IS N.G.V.D. 1929

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

UPPER RESERVOIR DAM

CAMP BROOK

Figure 2 of 2

REPRODUCED AT GOVERNMENT EXPENSE

APPENDIX C

PHOTOGRAPHS

FOR LOCATION OF PHOTOS, SEE FIGURE 1
LOCATED IN APPENDIX B

PHOTO NO. 1 - View of reservoir from the center of the dam.

PHOTO NO. 2 - Upstream face as viewed from right end of dam.

PHOTO NO. 3 - Upstream slope from right abutment.

PHOTO NO. 4 - Crest as seen from left abutment.

PHOTO NO. 5 - Downstream slope as viewed from spillway towards the left abutment.

PHOTO NO. 6 - Swampy area a downstream toe near right end of dam.

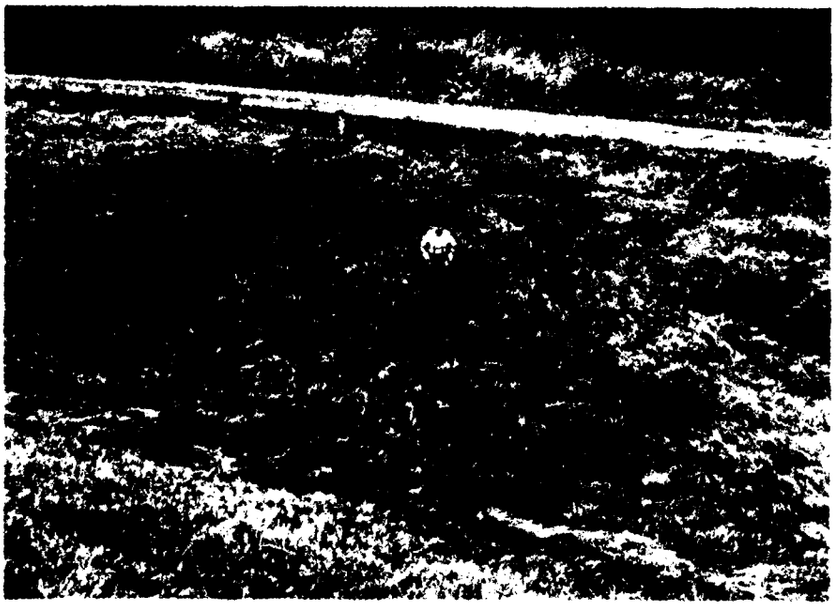


PHOTO NO. 7 - Wet area at toe of dam just to the left of the aerator jets.

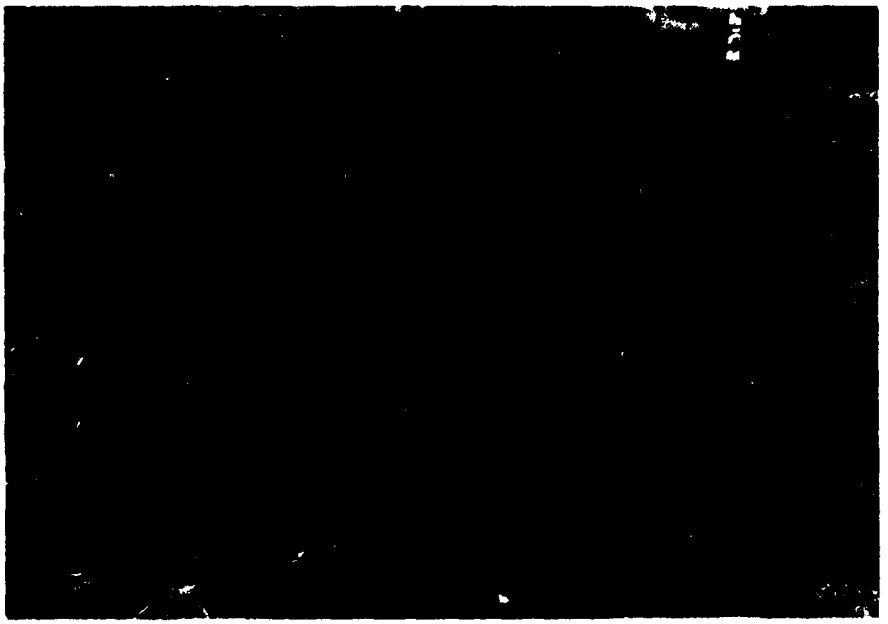


PHOTO NO. 8 - Close up view of Photo No. 7.

PHOTO NO. 9 - Upstream face of spillway weir and left training wall.

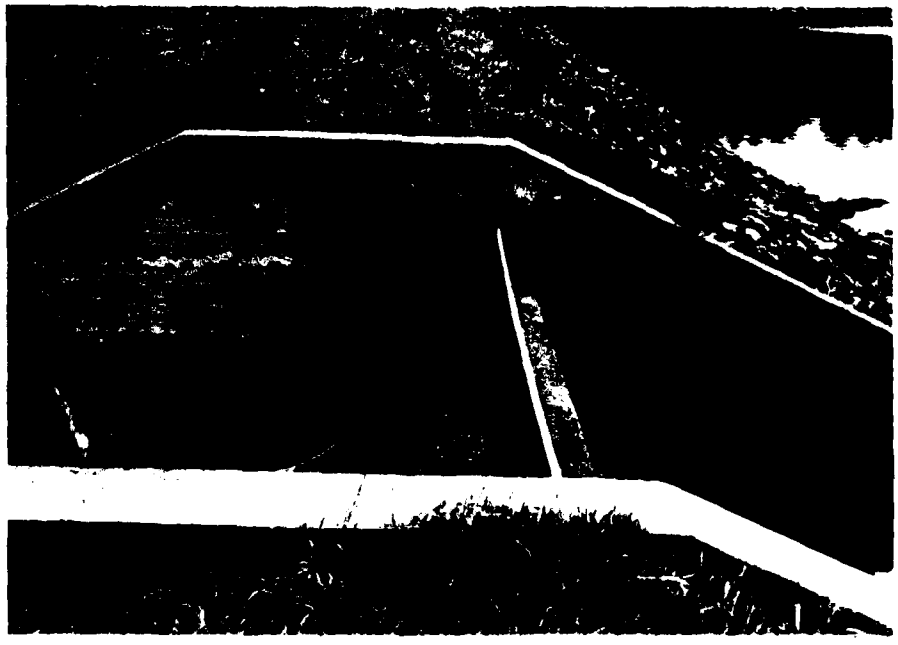


PHOTO NO. 10 - View of spillway weir crest.

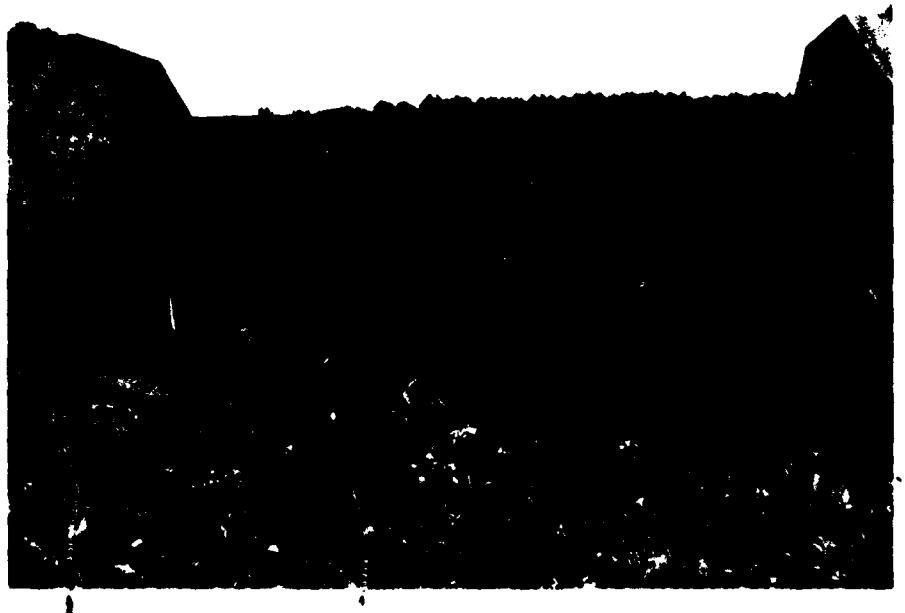


PHOTO NO. 11 - Downstream side of spillway structure. Note bedrock outcrop at base of weir.

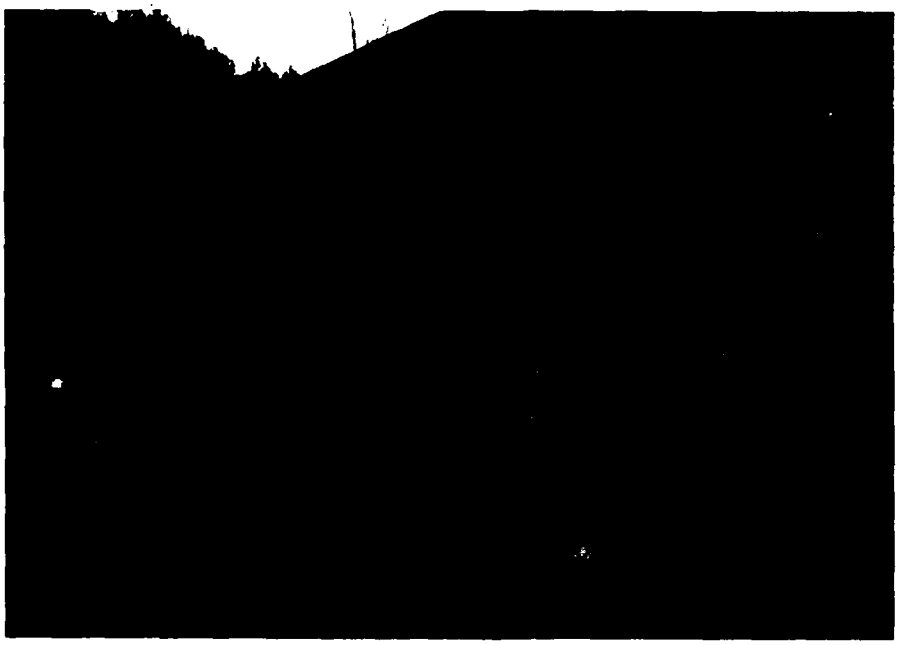


PHOTO NO. 12 - Crack in right training wall of spillway.

PHOTO NO. 13 - Downstream edge of spillway weir. Note close-up of bedrock outcrop.

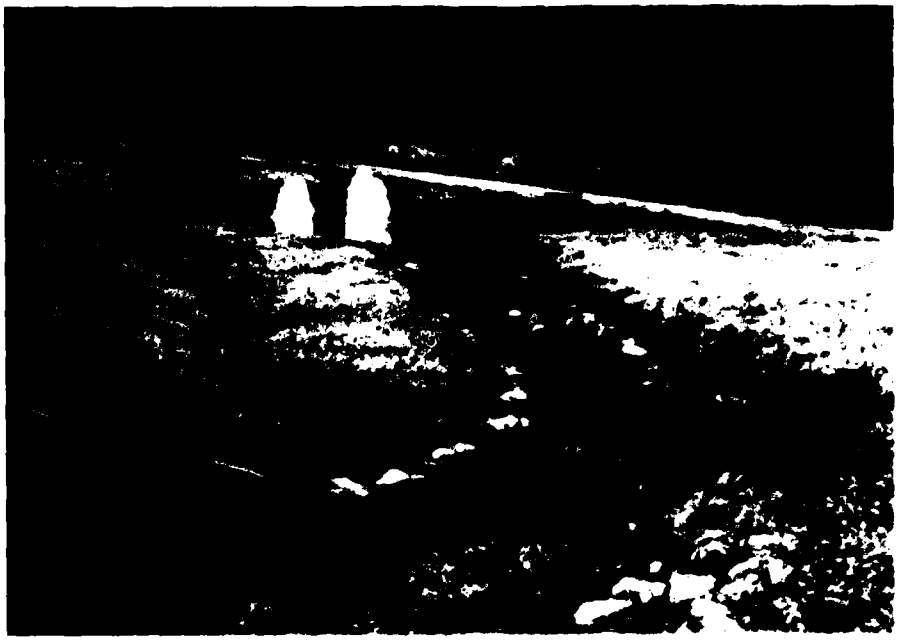


PHOTO NO. 14 - Spillway discharge channel.

PHOTO NO. 15 - Aerator jets.

PHOTO NO. 16 - Access road bridge over spillway discharge channel.

PHOTO NO. 17 - Channel downstream of access road bridge.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/13/79	Job No. 5765-11-14
	Checked by HM	Date 30 Nov 79	Sheet No. 1
For Upper Reservoir Dam			

Hydraulics & Hydrology

Upper Reservoir Dam is located on Camp Brook in the Town of Hanover, N.H., Grafton County, in the Connecticut River Basin. 2.67 mi u.s. of Conn River

Classification: Size = Small
Hazard Significant

Basin Data DA = .83 sq mi
Max elev 1280' MSL
Mountainous 150-400 ft/mi

Reservoir Surface Area @ Gauge @ spillway

Flash bd. Spillway	El. 788.3	- Stor	630 acre-ft
	Elev. 789.3	"	675 acre-ft.
	Elev 790.3	"	721 acre-ft
Top of Dam	790.5	"	730 acre-ft

Dam - Earth
Length 1340 ft
Max height 30 ft

Spillway - 25' length
Concrete weir
w/ Flash boards 1.4 ft high.

Outlet works. 2-10" pipes gated in MH's discharge to stream.

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/13/79	Job No 565-11-4
	Checked by TM	Date 11/13/79	Sheet No. 2
For Upper			

Step 1 Calculation of Test Flood Inflow

Classification Size: Small
Hazard: Significant

Hydrologic Evaluation Handbook Recommends

100 yr. Frequency flood to ½ PMF

Use ½ PMF as size is on higher end of classification range 730 sq ft vs max of 1000 sq ft
30 ft height max of 40 ft height

Use Mountainous Curve step Tributary area
As size of basin is outside PMF curve envelope use maximum value of 3000 csm.

Test Flood Inflow = $3000 \text{ csm} \times \frac{1}{2} \times .53 \text{ mi}^2$

= 1245 cfs.

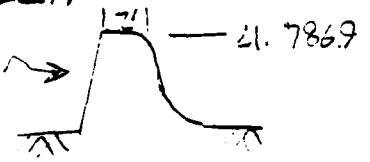
Total Runoff = ½ × 19 inch = 9.5 inches.

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/13/79	Job No. 325-11-14
	Checked by	Date	Sheet No. 3
For Upper			

Step 2 Calculation of Surcharge Effect

Consider: No Significant flow thru 2-12" ϕ outlet pipes.
No Flashboards in place 1.4' high

Spillway discharge weir $Q = CLH^{3/2}$



C = 3.25 w/o Flash
L = 25
permanent crest 786.9

$Q = 3.25(25)H^{3/2} = 81.25H^{3/2}$

With flashboards C = 3.44 Q at Elev 790.5 = 3.44(25)(2.27)^1.5 = 290cfs

Discharge over dam crest - $Q = CLH^{3/2}$

C = 3.08
L = 1340 - 25 = 1315
$Q = 3.08(1315)(H-3.60)^{3/2} = 4050.2(H-3.6)^{3/2}$

See figure 1

Stage-Discharge

Elev	H	Q spillway	Q dam	Total
786.9	0	-		-
788.0	1.1 ft	94 cfs		94 cfs
789.0	2.1	250		250
790.0	3.1	440		440
790.5	3.6	550		550
790.6	3.7	580	130 cfs	710
790.7	3.8	600	360	960
790.9	3.9	630	660	1290

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/14/79	Job No 525.11.14
	Checked by -1A	Date [illegible]	Sheet No 4
For Upper Reservoir			

Step 3 Calculation of Surcharge Effect

$Qp_1 = 1245$ cfs

Storage above dam crest vertical prism. Lake Surface 4.6A

Start routing with water surface at the spillway crest

$$Qp_2 = Qp_1 \times \left(1 - \frac{Stor}{9.5}\right)$$

$$Stor_{(in)} = \frac{\text{Storage AF} \times 12\,in/ft}{640\,ac/mi^2 \times .83\,mi^2} = \text{Storage}\,(.02259)$$

Routing Curve See fig 1

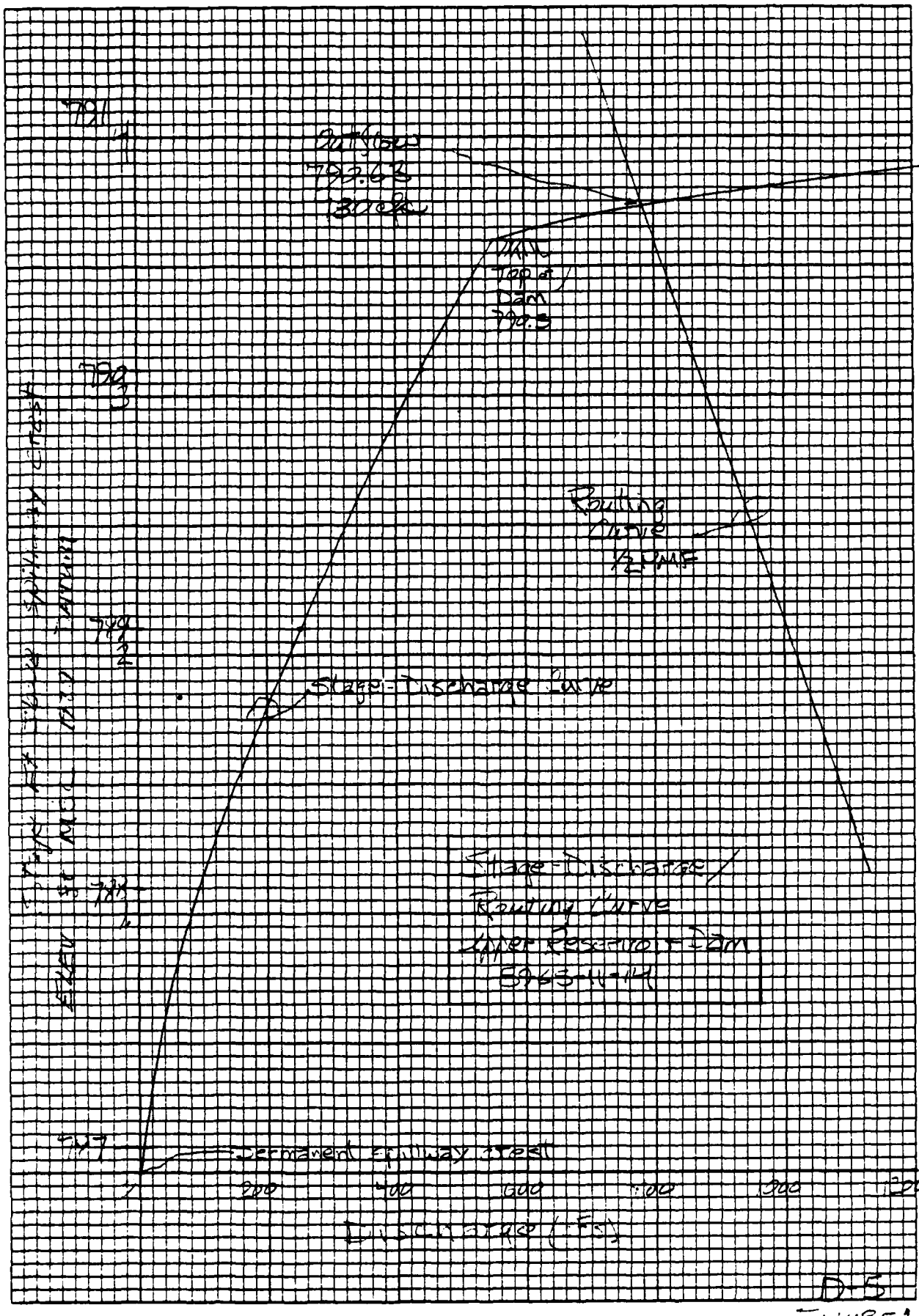
Elev	Storage	Stor(in)	Qp_2
786.9	0	0	1245 cfs
788.3	50	1.13	1100
789.3	95	2.15	960
790.3	141	3.19	830
791.3	187	4.22	690

See Figure 1 for Outflow 780 cfs

Stage 790.63 in 790 C.F.

Overtops Dam by 0.1 ft.

Spillway 71% of Routed test flood outflow


Stage-Discharge Curve
Routing Curve
Lower Reservoir Dam
Permanent Spillway Crest
Discharge (cfs)
200
400
600
800
1000
1200

D-5

FIGURE 1

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RPY	Date 11/14/79	Job No 5205-11-14
	Checked by HH	Date	Sheet No 5
For Upper Reservoir			

Downstream Damage Assessment

Step 1 Reservoir Storage

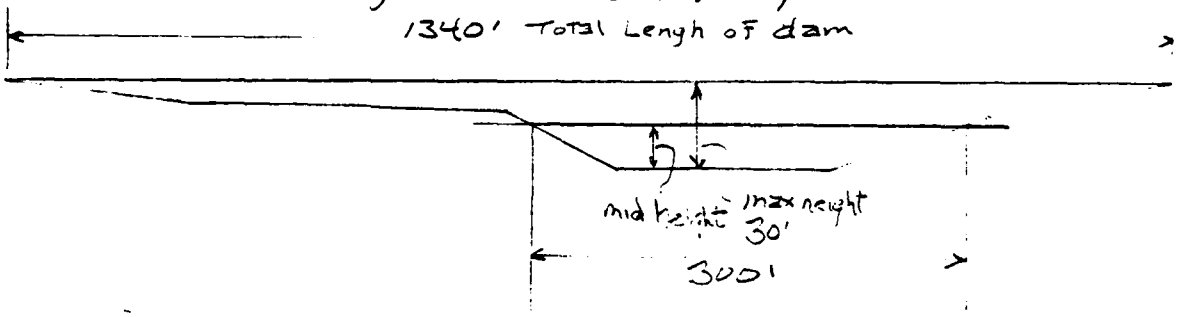
Top of Dam 790.5 Storage = 730 acre ft

Step 2 Breach Outflow

$Q_{breach} = 8/27 \sqrt{g}\, w_o\, y^{3/2}$

w_o = 40% of the dam length at mid height

y_o = max. height stream bed to top of dam.



$Q_{breach} = 8/27 \sqrt{g}\, 40\%(300)(30)^{3/2}$ = 33150 cfs

$Q_{spillway}$ = 550 cfs

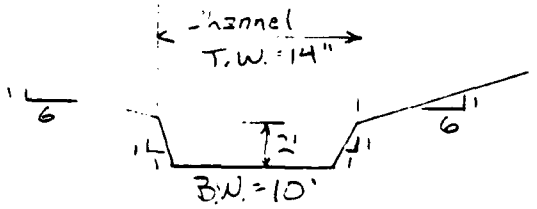
Total breach 33,700 cfs.

Step 3 Stage - Discharge

Reach length = 1300'

S = .05-5%

n = .07 channel & overbank



Stage - Discharge see fig 2

Stage ft	Discharge cfs
2	170 cfs
5	1250
10	7900
13	16250
15	23700
17	33700

Step 4 Reach Outflow

Q_{P_1} = 33,700 cfs S = 730 cu ft L = 1300'

Stage 17.0 ft area = 1520 sq ft

$V_1 = \frac{1300' \times 1520 \text{ sq ft}}{43560} = 47$ ac-ft ~ $\frac{73}{2}$ = Peak OK

$Q_{P_{2T}} = 33700\left(1 - \frac{47}{730}\right) = 31,530$ cfs

Stage 2 = 16.6 ft area 2 = 1510 sq ft

$V_2 = \frac{1300 \times 1510}{43560} = 45$ ac-ft

Ave = 46 ac-ft

$Q_{P_2} = 33700\left(1 - \frac{46}{730}\right) = 31,600$ cfs

Stage 16.6 ft

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/12/79	Job No
	Checked by	Date	Sheet No

For

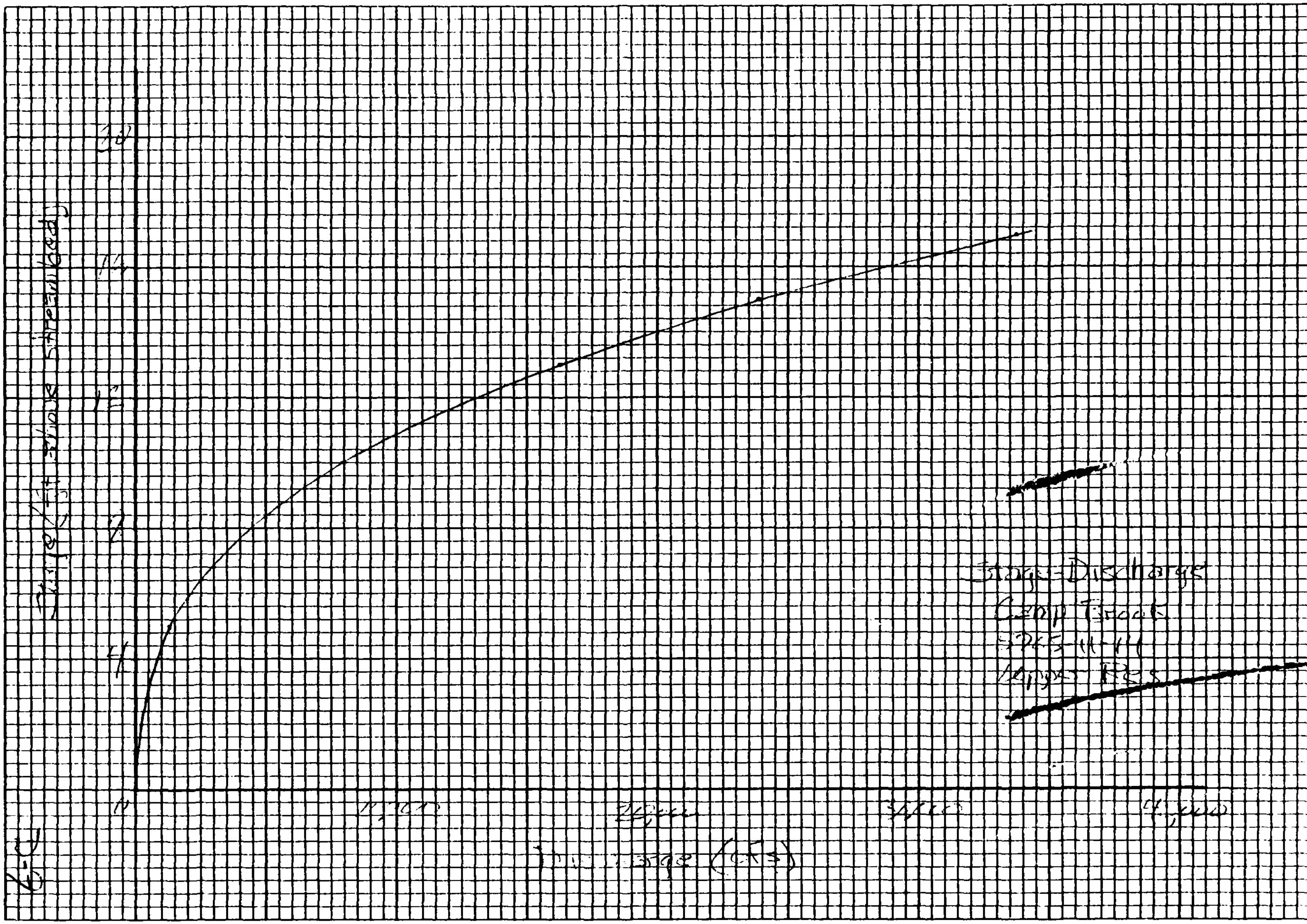
Lower Reservoir Defines the end of the Upper Reservoir Drainage area.

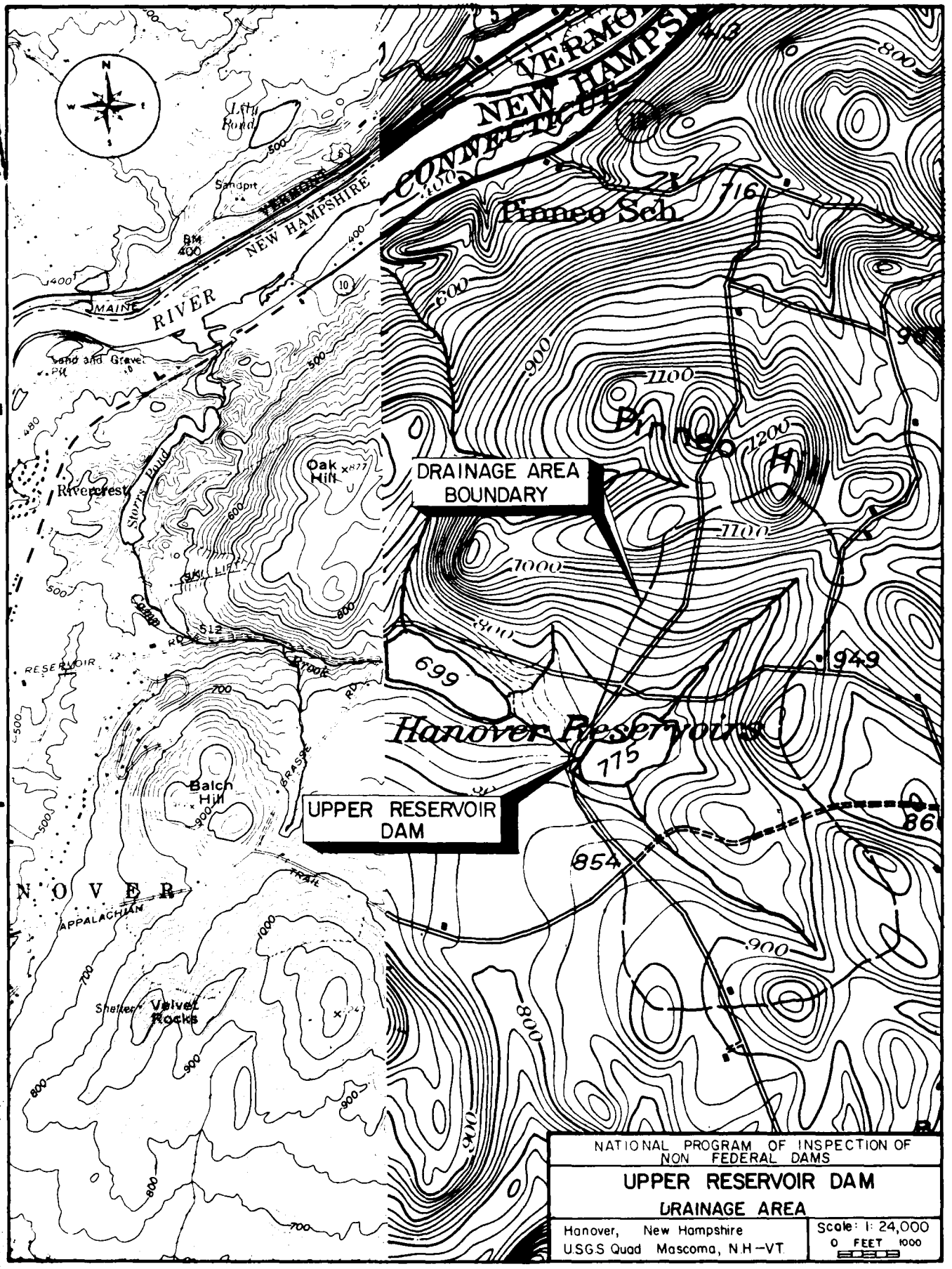
If the water level of Lower Reservoir is at the permanent spillway crest when the Upper Reservoir breaches about 34 acre × 3.5 ft = 119 acre-ft of water would be needed to overtop Lower Reservoir.

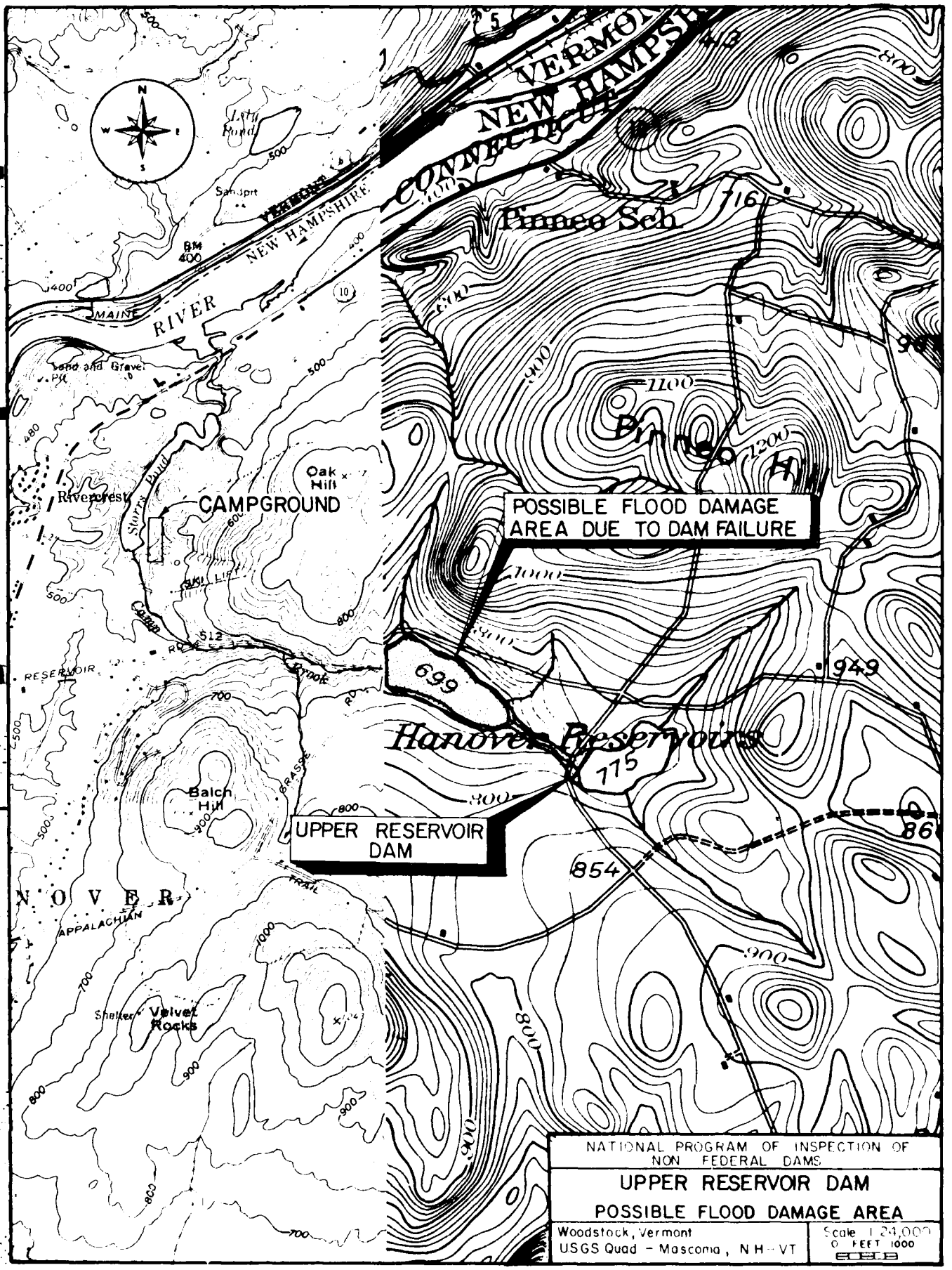
Consider the breach discharge of 31,600 cfs
minus Lower Res. weir spillway capacity 250
31,350 cfs

Time to overtop with 3.5 ft $\frac{119 \times 43560}{31,350} = 165$ sec
2.75 min

The Time in which Lower Red would be overtopped is not necessarily accurate; however, it does show that Lower Red Dam would be overtopped should Upper Red Dam fail.


Stage-Discharge
Camp Brook
Upper Res
Stage (ft above streambed)
Discharge (CFS)


DRAINAGE AREA BOUNDARY
UPPER RESERVOIR DAM
Hanover Reservoirs
Pinneo Sch.
Pinneo Hill
Oak Hill
Balch Hill
Rivercrest
Velvet Rocks
Shelter
Sandpit
Sand and Gravel Pit
RIVER
NEW HAMPSHIRE
VERMONT
CONNECTICUT
MAINE
APPALACHIAN TRAIL
RESERVOIR
699
775
854
949
1100
1200
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
UPPER RESERVOIR DAM
DRAINAGE AREA
Hanover, New Hampshire
U.S.G.S Quad Mascoma, N.H.–VT.
Scale: 1: 24,000
0 FEET 1000



NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

UPPER RESERVOIR DAM

POSSIBLE FLOOD DAMAGE AREA

Woodstock, Vermont
USGS Quad - Mascoma, N.H.-VT

Scale 1:24,000
0 FEET 1000

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR. DIST.	STATE	COUNTY	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
NH	49	NED	NH	009	02				UPPER RESERVOIR DAM	4342.9	7214.3	30NOV79

POPULAR NAME	NAME OF IMPOUNDMENT
	UPPER RESERVOIR

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	08	CAMP BROOK	HANOVER	1	8500

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
REPG	1924	S	50	50	730	580	NED	N	N	N	N	

REMARKS
21-RECONSTRUCTED IN 1950

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
2	1340	U	25	550	29000											

OWNER	ENGINEERING BY	CONSTRUCTION BY
HANOVER WATER WORKS CO	WESTON + SAMPSON	FRANK A WHITCOMB

REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
HOWARD NEEDLES TAMMEN HERGENDOFF	26OCT79	PL92-367

REMARKS

END

FILMED

8-85

DTIC